RELATION BETWEEN BOUGUER GRAVITY ANOMALIES AND REGIONAL TOPOGRAPHY IN NEVADA AND THE EASTERN SNAKE RIVER PLAIN, IDAHO

By DON R. MABEY, Denver, Colo.

Abstract.—An analysis of the relation between Bouguer gravity-anomaly values and regional elevation for 57 gravity stations in Nevada indicates that the Bouguer anomaly value for stations not effected by low-density Cenozoic rocks is approximately equal to 3 mgals plus −0.032 mgal per ft multiplied by the average elevation within 64 km of the station. The analysis of local anomalies is facilitated by the removal of a regional variation, computed by this method, from the measured anomalies. A similar treatment appears applicable to data from the eastern Snake River Plain if 35 mgals is added to the computed anomaly value.

The correlation between gravity anomalies and regional topography was recognized by early workers in this field. Putnam (1894) and Gilbert (1900), studying the early pendulum gravity data in the United States, followed earlier work by Faye and applied a correction to the free-air anomaly for a slab of material with a thickness equal to the difference between the elevation of the pendulum station and the average elevation surrounding the station. This is equivalent to adding to the simple Bouguer anomaly the effect of a slab of material extending from sea level to the average elevation around the station. Putnam determined averaged elevations over circular areas 100 miles in radius and Gilbert over areas 30 miles in radius. They found that this correction produced anomalies that averaged near zero. Subsequently, several methods of computing isostatic reductions, based on regional topography, were developed, and the use of corrections based on simple average elevation was largely abandoned. (For discussion of the historical development of the idea of isostasy see Heiskanen and Vening Meinesz, 1958, p. 124–146.) Woollard (1959) presented a graph of worldwide data showing the correlation of Bouguer gravity values and surface elevation. This graph clearly shows an inverse dependence of the Bouguer anomalies on elevation, but the scatter is large.

The inverse correlation between regional topography and Bouguer gravity anomalies in part of the Basin and Range province has been described by the writer (Mabey, 1960) previously. A quantitative analysis of the correlation in the Nevada portion of this area has proved useful in the separation of local gravity anomalies from regional anomalies. The general techniques used for gravity studies in Nevada were found to be applicable to similar studies in the eastern Snake River Plain, Idaho.

NEVADA

From about 10,000 gravity stations in Nevada, 57 were selected as being representative of the stations on pre-Tertiary bedrock. These stations are not greatly affected either by local anomalies produced by low-density fill underlying the basins, or by large terrain effects. The elevation of each station is known, and the average elevation of circular areas of four sizes around each station (within a radius of 16, 32, 64, and 128 kilometers, respectively) was determined. Observed gravity relative to the gravity at the airport base station at Ely, Nev., is known to within 0.5 milligals. Free-air and Bouguer corrections were computed by standard methods, assuming a density of 2.67 grams per cubic centimeter in the Bouguer reduction.

By the methods of least squares the linear relationships between (1) the Bouguer anomaly values and (2) the station elevation and elevations averaged over the four different-sized areas were determined. The results are summarized in table 1. As the area used in determining the average elevation is increased, the slope (milligals per foot) of the linear relationship becomes more negative, and the intercept at sea level increases. For an area with a radius of 128 km the slope is approximately equal to the negative Bouguer correction coefficient corresponding to a density of 2.67 g per cm^3; the intercept is near zero for a radius of 64 km. The standard deviation is lowest for a radius of 64 km but only slightly higher for 32 km.

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A plot of Bouguer anomaly values and elevations averaged over areas 64 km in radius is shown on figure 1. With one exception, Bouguer anomaly values for all the stations are within 15 mgals of the line determined to be the best linear fit for the data. The exceptional station is in an extensive area of high-density bedrock.

TABLE 1.—*Summary of linear relation between Bouguer anomaly values and the average elevation of areas of different radius in Nevada*

Radius (km)	Slope (mgals per ft)	Intercept (mgals)	Standard deviation (mgals)	Range in elevation (feet)
0	−0. 022	−54	16. 1	1, 400–7, 500
16	−. 024	−37	12. 6	2, 100–7, 500
32	−. 026	−29	9. 9	2, 100–7, 300
64	−. 032	+3	8. 2	2, 600–6, 800
128	−. 034	+16	13. 4	3, 000–6, 600

The Bouguer anomaly value for locations in Nevada not effected by basin fill or other local anomalous masses can generally be predicted within 15 mgals by multiplying the average elevation relative to sea level of an area 64 km in radius around a station by −0.032 mgals per foot and adding 3 mgals, which is the intercept at sea level indicated in figure 1. Relative values over areas of several hundred square miles can usually be predicted within 5 mgals. In several areas in Nevada, study of the relation between Bouguer anomaly and regional elevation has proved to be an effective technique of isolating negative gravity anomalies associated with Cenozoic basins from the regional anomalies related to regional topography. The data from Nevada confirm the conclusion by Pakiser (1963, p. 5753) that: "For a region in isostatic equilibrium, no information on broad variations in crustal thickness can be obtained from gravity that cannot be inferred directly from regional variations in altitude above sea level."

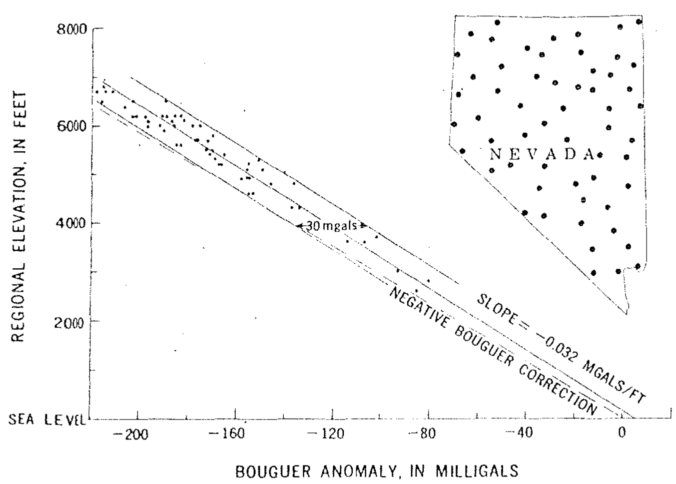

FIGURE 1.—Bouguer gravity anomaly and average elevation of areas 64 km in radius surrounding representative stations in Nevada. Map shows station locations. Linear relation was determined by method of least squares.

As an independent check of the application of this technique for estimating regional gravity anomalies, data from 12 U.S. Coast and Geodetic Survey pendulum stations in Nevada and adjoining parts of Utah and California were analyzed. The regional elevation was computed and a correction equal to the regional elevation multiplied by 0.032 mgals per foot minus 3 mgals was applied to the Bouguer anomaly. The results are summarized in table 2 and compared with the Pratt-Hayford isostatic anomalies. The data from these 12 stations indicate that the gravity values in this part of the Basin and Range province can be predicted as accurately by computing average elevation as by computing a Pratt-Hayford isostatic correction. Average elevations can be computed quickly and easily—isostatic corrections require much greater effort, unless the complete data for terrain corrections using Hayford zones A–O are available.

TABLE 2.—*Average Bouguer anomaly corrected for regional topography and average isostatic anomalies for 12 U.S. Coast and Geodetic Survey pendulum stations in Nevada and adjacent parts of Utah and California*

[Pratt-Hayford anomalies from Duerksen (1949)]

	Bouguer anomaly corrected for regional topography (mgals)	Pratt-Hayford anomaly (mgals) for depth of compensation of—			
		56.9 km	96 km	113.7 km	96 km [1]
Average anomaly (without sign)	8. 5	8. 3	15. 7	19. 6	12. 5
Average anomaly (with sign)	0	−4. 7	−14. 3	−18. 6	−9. 7

[1] Corrected for indirect effect.

EASTERN SNAKE RIVER PLAIN, IDAHO

Gravity surveys of the Snake River Plain (Hill and others, 1961; Hill, 1963; LaFehr and Pakiser, 1962; and Bonini, 1963) have defined an extensive gravity high over the plain upon which are imposed local anomalies. The extensive high is obviously related to the low topography of the plain and probably reflects isostatic compensation here. Before the local gravity anomalies that are superimposed on the regional anomaly can be analyzed, they must be separated from the more extensive anomaly. Hill (1963), in an analysis of the data from the western part of the plain, assumed a regional anomaly based on the extrapolation of regional gradients on the sides of the plain. In the eastern part of the Snake River Plain an attempt has been made to remove the portion of the anomaly obviously associated with topography by computing average elevations and applying a correction for the average elevation to the Bouguer anomaly values.

From low values of about −230 mgals over the high topography to the north, the Bouguer anomaly values rise over the Snake River Plain to a maximum of −70 mgals in the western part and about −130 mgals in the eastern part. South of the plain the values decrease, but not as markedly as to the north. A profile trending north-northwest across the plain near Pocatello, Idaho, illustrates the general character of the anomaly in the eastern Snake River Plain (fig. 2).

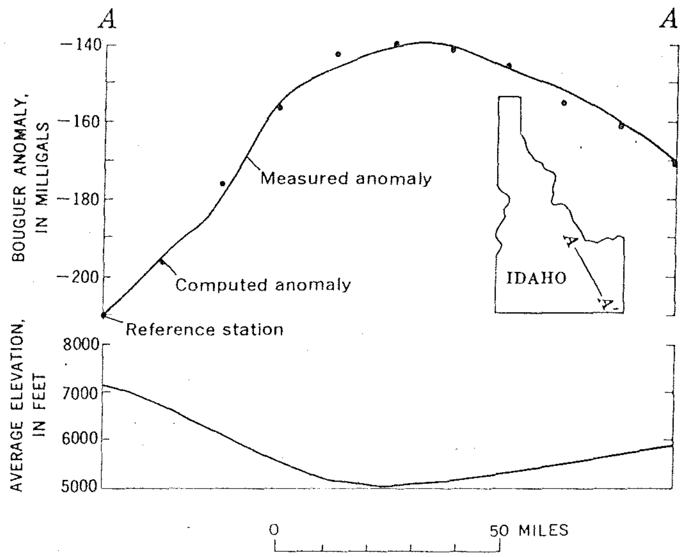

FIGURE 2.—Bouguer gravity profile *A–A′* across the eastern Snake River Plain. Elevations are averaged over areas 64 km in radius. Computed anomaly values were obtained by adding the Bouguer anomaly at the reference station to the product of the negative Bouguer correction coefficient (−0.034 mgal per ft for $\rho = 2.67$ g per cm^3) times the difference between the average elevation around the point and the average elevation around the reference station.

In an effort to determine how much of the anomaly over the plain was directly related to the regional topography, average elevations were computed for circular areas 64 km in radius. The northwest end of the profile was taken as the reference station, and the difference between the average elevation of this point and of points at 20-km intervals along the profile was determined. This elevation difference multiplied by the negative Bouguer correction coefficient (−0.034 mgal per ft) was added to the anomaly value of the reference station. The good agreement between this computed anomaly and the measured anomaly indicates that the anomaly making up the regional high over this part of the Snake River Plain is closely related to the regional topography. Local residual anomalies computed by removing this regional anomaly probably reflect near-surface mass anomalies. However, a significant part of the regional anomaly may also reflect extensive mass anomalies that may extend to near the surface but which are systematic with topography.

Along the profile in figure 2 all the Bouguer anomaly values are about 35 mgals higher than would be computed by multiplying the average elevation by the negative Bouguer correction coefficient. However, the relative Bouguer anomaly correlates well with the relative average elevation along the profile. The generally high Bouguer anomaly values in eastern Idaho relative to the values in Nevada at similar regional elevations illustrate the necessity of investigating the relation between average elevation and gravity anomalies on a region-by-region basis rather than attempting to determine a universal relationship that can be applied to all areas.

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